Hints and Tips for Competing in the Lightweight Autonomous Sumo Robot Class

Robot Competitions...
Everyone loves to see the robots in action. It can be absolutely mesmerizing to watch these smart little machines running around accomplishing a goal. Everyone wants to get in on the fun, but who wants to become a "rocket scientist" in the process? How do you get started? What do you do for parts, and how much is this going to cost? Well things are changing in the field of educational, or hobby robotics. The materials and equipment are becoming more readily available and more affordable. But the best part is it's becoming much easier to do. You no longer need to learn a complex or cryptic programming language in order for your robot to move about intelligently. It's easier, thanks to a little microcontroller the size of a postage stamp that can be programmed in Basic, hence the name Basic Stamp. The program sort of reads like a book, for example, the section of code that stops the robot from moving out of the ring might look like this; if line_sensor = 1 then backup. Pretty simple right... Well it gets better because, there are programs already written for the sumo competition that can be modified to suit you individual taste.

More about the Contest
The Lightweight Class is based on an affordable robot kit called the Micromouse available from my company, Lynxmotion, Inc. However, the purchase of this kit is not required. You may certainly home brew your own small mobile base from scratch. It's a simple two servo differentially steered mobile base. The requirement for this class are as follows;

- Limit the overall size of the robot to within 20cm x 20cm or 8" x 8" with no height restriction.
- Limit the weight of the robot to under .75kg or 26.4oz.
- Limit the wheel diameter to 1.5".
- Limit the combined rated torque of the servos to 100 oz./in.
- Servo voltage is not restricted, most will use 9 volts.

The Kit
The Micromouse kit is available for a quick and affordable jump start to getting the robot base moving. There is plenty of opportunity for customization and modification, so the "kit" robot quickly becomes individualized. But before we get into the nuts and bolts of the robot, we should talk about the strategy involved in autonomous sumo competition. Note, checkout our website at;
http://www.lynxmotion.com

The Strategy
The object is to push the opponent out of the ring. There are different methods of accomplishing this. One strategy is to locate the opponent, navigate towards him, make contact and push him out of the ring. A simpler approach would be to move about in a random fashion. When contact is made push the opponent out of the ring. Both of these methods require sensing of the border to prevent running right off the edge. While there are certainly other methods, we will focus on these two.

The easier of the to methods is the RMC, Random Motion till Contact. This strategy can use a single ended approach, meaning the robot has a front with a bumper switch, and a rear with no bumper switch, or a double ended approach, meaning the robot has a bumper switch on the front and rear and can push from either end. The obvious drawback to the single ended design is when it detects the ring border, it has to backup and turn about 180 degrees, then start going forward again. The robot is vulnerable to attack when reversing and turning around. Either RMC approach can make a very effective sumo robot design.

The more difficult method is the SAD, Search And Destroy approach. The robot has to be able to actually "look" for the opponent. There are a few methods of doing this with reflective IR sensors designed for measuring the proximity and or distance, as well as modified sonar units made for Polaroid cameras. Some of the problems with using the sonar units are, they are too slow, they are large and they use a lot of current when operating. Therefore most use IR reflective sensors for opponent locating. Lynxmotion makes an IR sensor called the IRPD that works pretty well for this purpose, and there is a new Sharp IR sensor PN# GP2D05 that is being used with good results. The idea here is after the initial 5 second delay, the robot begins spinning around while checking an IR sensor for a reflection. Immediately upon "seeing" the opponent the robot stops spinning and starts off in the general direction. This may be enough to make contact and eventually push the opponent off the ring, however the optimal situation would be to track the opponent and make direction corrections as you move. It's not as difficult as it sounds. The IRPD has three areas of detection, left, right and both for front. Just steer into the opponent as directed by the sensor. If the sensor does not detect anything the spinning behavior should have a time limit, so the robot doesn't spin indefinitely. If the robot missed the opponent it should begin moving forward while still looking. If the ring border is detected, the robot should stop, backup and do another spinning search as before.

Either approach should include a smart bumper. The bumper should be hinged to allow two switches to be attached. This allows the microcontroller to distinguish which side the robot has made contact with. This information is useful to track the moving target by turning into the direction of contact. However, precautions must be taken to ensure the robot doesn't get caught in a deadlock by hitting the opponent broadside, and constantly turning in a large circle. Now, on to the nuts and bolts of the project.
What's in there?
The robot is made up of three basic building blocks; the drive train and chassis, the brains, and the sensors. We will cover each one to some detail. Pictured to the right are some examples of what can be done in your own robot design.

The Chassis and Drive Train
The chassis is made from a machinable PVC based plastic called Sintra. It comes in many colors and is very easy to work with. You can easily cut it with a band saw, and drill holes with a Dremel tool. It is remarkably light weight, yet surprisingly durable. I sandwich the drive servos in between two sheets of Sintra using cross members made from plastic tubing called Plastro. I found that a #4 screw would self tap into the 3/16” plastic tubing with little effort. If you are home brewing a robot or modifying a Micromouse remember the size limitation of 8” x 8” as you plan the mechanics. The drive servos are actually made from an RC servo, such as the ones used in remote controlled airplanes. However, there is a catch, the servo was designed to position an output shaft within a range of 180 degrees of rotation. Therefore, the servos will require a hardware modification in order to turn continuously. There is information in the kit for doing this, and there are instruction on the internet as well. Add the 1.5” foam rubber tires to the round servo horn and you’re ready to roll, so to speak.

Servo information: http://www.seattlerobotics.org/guide/servos.html
Servo modification: http://www.seattlerobotics.org/guide/servohack.html

The Brains
The thing that makes the robot know what it is supposed to be doing is called the microcontroller. For the Micromouse we made a kit version of the popular Basic Stamp called the First Step Micro that has been specifically designed to control small robots. This means you don’t have to breadboard any of the circuitry. Just plug things in as you build the robot. This document as well as the manuals that come with the Micromouse kit are no replacement for the actual programming manual. However, I do include a quick start guide. The programming manual is available from Parallax, the maker of the Basic Stamp computer, for free download from the internet. Programming this little computer is a breeze thanks to some clever engineering by Parallax. Just plug the download cable into your PC or laptop and the First Step, load or type in your program, and press Ctrl-R. The First Step accepts the download, and automatically begins running the new program. Making changes is as easy as typing the changes, then pressing Ctrl-R as before. The First Step stops running, accepts the new code, then begins running the modified code again without even a jumper change. Remove the download cable at any time to run autonomously. Don’t worry about the program, it is stored in an EEPROM and is safe from power loss.

Parallax: http://www.parallaxinc.com

The Sensors
In order for the robot to know what’s going on around it, you need to provide some sensory input. An easy way to “see” the 2” white border surrounding the 3’ ring is to use an existing kit normally use for doing line tracking. The Tracker kit needs minor modification to be used for this. It is really simple, you just add wires to the IR sensor pairs so you can mount them around ¼” from the surface in the front and or rear of the robot. The IRPD, which is normally used to avoid hitting obstacles, is connected and programmed in such a way to that it moves the robot toward the obstacle or opponent. Other ways the robot can tell what’s going on around it is with bumper switches. A simple snap switch connected to the front bumper works well, and is easy to connect to the electronics.

The Big Picture
It is probably time for a big picture wrap up of the mechanics and electronics. Keep your connections short and tightly bundled. You certainly don’t want to have a wire get caught up in the moving parts just when you start pushing the opponent. Use sound construction techniques. Super Glue and double sided tape are fine provided you have enough surface area to make good contact. Be imaginative in the design, the best design may be sitting in someone's gray matter. Get the most power as possible from the servos. They are rated for 6 volts, but the servo is an analog device with certain tolerances built in. It is the norm for robot builders to run these at up to 9 volts. This is achieved by powering the unit with 6 alkaline "AA" cells. I have had servos break from time to time, but not from running them at 9 volts. Add the extra weight you are allowed. This will provide much more traction when it’s time to push. Be prepared, don’t wait until the night before the event to “finish” the robot.

Finishing up
I hope you have found this document to be useful. Please let me know if there is anything I can do to help you in your preparation for the contest. Thanks, Jim

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Students doing some last minute fine tuning.

The line at the laptop slowed things up a bit

Large feelers to find the opponent and a bumper to push with.

What can I say?

The scoop is a difficult offensive weapon to face in the ring!